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RESEARCH PAPER P-322

MANNED BARRIER SYSTEMS: A PRELIMINARY STUDY (U)

Charles C. Lauritsen
Thomas Lauritsen
Matthew L. Sands

August 1966

INSTITUTE FOR DEFENSE ANALYSES
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CONTENTS

APPENDIX

I. MANNED BARRIER SYSTEMS

A. RECOMMENDATION

It is recommended that a systematic, large-scale attack be mounted on the engineering design of barrier systems and on the development of suitable components for barrier systems. Particular attention should be directed toward:

- A barrier system of high effectiveness, which would permit sealing off the border of South Vietnam against infiltration of personnel and supplies. We envision such a barrier to be installed and maintained initially by American forces, but possibly it would be turned over eventually to Vietnamese forces or to an international control force.
- Temporary or semipermanent barriers to permit sealing off large land areas containing heavy concentrations of regular Viet Cong or North Vietnamese forces, as for example, in the highland regions or in the so-called "war zones."
- Perimeter defensive barriers to protect friendly bases, camps, or population centers.
- Barriers to be laid and maintained in enemy territory to interdict roads and other lines of communication.
- Barriers to inhibit or give warning of enemy action against roads, railroads, and waterways in friendly hands.

In each case, emphasis must be placed on minimizing the manpower required in construction, maintenance, and enforcement. Advantage should be taken of U.S. superiority in technical resources and particularly of the high mobility afforded by our command of the air.

As used here, the term "barrier" is taken to include a wide range of mechanisms, which in some degree deny or retard enemy passage across a given line. Depending on the circumstance, a barrier might range from a virtually impenetrable

"fence" protected with highly mobile forces, to an automated, lightly fortified line, to the mere use of a sensor system that reports enemy penetration. Although the barrier is often used in conjunction with other types of operations, it should be considered as a weapons system of its own, substituting physical obstacles, remote reporting, and automatic response for combat manpower.

The application of barriers in military operations is not new, of course, and extensive use of barrier techniques has been made in Malaya, Korea, Vietnam, Algeria, and many other places.[1] Barriers also have an important place in naval operations, as in shipping blockades, in mining, and in anti-submarine operations. However, like all weapons systems, the concept and application of barrier systems need to be reviewed from time to time in the light of changing requirements and technological advances.

In the following discussion, we argue that the character of the conflict in Vietnam is such as to demand a far greater use of barriers than is the case in more conventional operations, and that they can be put there to both tactical and strategic advantage in bringing about a favorable termination of hostilities. At the same time, we argue that technological advances, particularly in the use of helicopters to move troops quickly, may make barrier systems far more economical in manpower than has been true in the past. Other developments which can be used to improve the efficiency of barriers include sensors, moving-target radar, infrared detectors, and night-vision devices. Still further developments can confidently be expected as the requirements are clarified.

Finally, it is our view that barrier systems developed for use in Vietnam could constitute an important resource for

[1]See the appendix for a description of the Algerian barrier.

dealing with other insurgency or guerrilla conflicts in which the United States might become engaged in other parts of the world.

B. BARRIER CONCEPTS

National Boundary Barrier

Here we think of a more or less continuous physical barrier, patrolled by a minimum force, supported as necessary by highly mobile forces of adequate strength to deal with any attempted large-scale penetrations. The barrier would generally follow the national border, except where convenience of construction or terrain advantages favor deviations inward.

It is reasonable to expect that a barrier of this general character should be constructed sooner or later in Vietnam, if for no other reason than to permit monitoring of a cease-fire agreement. An example is to be found in Korea, where even now, a system of barriers separates North and South Korea to minimize enemy infiltrations. The construction of an extended barrier in South Vietnam would be a large and costly operation, even in peacetime, and it will be still more difficult under the present conditions of conflict. Still, it may be argued that the advantages to be gained by an effective border control are sufficiently great to justify pressing forward with the construction at least of key segments, even during active hostilities.

The following are some of the advantages of such a course:

- A barrier along the border of South Vietnam would be effective in preventing buildup of hostile forces and in denying them needed supplies. Present interdictory efforts apparently do not prevent replacement of casualties, nor do they cause serious shortages of supplies to the enemy. Clearly, a better interdiction would be worth a considerable effort, in the form of either a manned barrier or of air-laid and air-maintained barriers across lines of communication.

- An effective isolation of the hostile forces in South Vietnam from support from North Vietnam would not only permit a meaningful attrition of the hostile regular forces in the south, but it would in all likelihood force them to abandon dispersed guerrilla tactics in favor of massing large forces in an attempt to destroy a section of the barrier. The barrier would thus force them to "come out and fight" under conditions where our superior firepower, armament, and mobility would work to our greatest advantage.
- A decisive interdiction of outside support would have a strong effect on the morale of the enemy and his will to continue the conflict.
- A national boundary barrier would strengthen our contention that we are fighting against external aggression. Enemy penetration would provide convincing and unmistakable evidence of such aggression and greatly strengthen our international position.
- If an effective border barrier can be maintained by U.S. forces, it should eventually be possible to leave the problem of the pacification in the south to the South Vietnamese. Such a division of activities would reduce significantly the deleterious social and economic effects of the U.S. presence now diffused throughout the south. It would also foster a more rapid establishment of internal administration and control by the South Vietnamese government.
- The existence of a physical barrier would make it possible for us to accede to a cease-fire with effective international control.
- The successful completion of a barrier at the national boundary would mark a decisive step toward terminating the war without further escalation. Visible evidence of progress on the barrier will sustain U.S. popular support over the inevitable periods of disenchantment and internal political strife that lie before us.

In view of the varied, and in some places most inhospitable, nature of the terrain along the natural frontier, the character of a border barrier will vary a great deal from place to place. It is entirely possible that only a fraction of the border needs actually to be furnished with a continuous physical barrier and that many places, where infiltration trails are restricted, can be controlled by suitably disposed watch posts or some form of air-supported interdiction.

Clearly, an assessment of the problem must include an examination of the most critical infiltration routes, and presumably, initial deployment of the system should emphasize these regions.

Several critical areas along the border are already controlled to some extent by special forces camps. Consideration should be given to possible link-ups of these camps to seal the intervening regions. Ultimately, a completely effective barrier will require control of all possible crossing points, but a great deal can be gained by making the first installations at points where they cause the maximum inconvenience to the enemy.

Tactical Barriers

We believe that a set of suitable barrier systems that could be deployed extensively within South Vietnam could be valuable in prosecuting the war against the hostile main force units already in the south. We shall refer to these as "tactical barrier" systems.

The various objectives of the war in the south -- to secure our bases and sources of supply, to protect the major population centers from being overrun, and to reduce the area of control of the enemy forces -- could all be prosecuted with improved effectiveness if barriers were available. Such barriers could be deployed to provide a perimeter defense or a quarantine of large areas without tying down large numbers of troops in defensive positions, and they would thereby release the maximum number of military forces for offensive operations.

In the immediate future, our primary objective clearly must be to ensure that the enemy is prevented from organizing his forces in sufficient strength to achieve any direct military victories. In view of the current buildup of enemy forces, of the evidence that he is stockpiling supplies, and of the evidence that he is organizing divisional and larger

structures, we must maintain a strong defensive position around our holdings, and at the same time, we must engage in a policy of moving our forces about in "spoiling" operations wherever substantial enemy groupings can be found. If we are successful, as we must be, in forcing the enemy to abandon his hopes for a quick victory through large-scale conventional attacks, his recourse must be to drop back to guerrilla warfare, conducting his operations with small units and striking only where he has local superiority. In our view, this is the stage at which the use of tactical barriers as an alternative to "search and destroy" techniques can play their most decisive role.

The basic element in the guerrilla's offensive strategy, and the distinct advantage he enjoys, is that he is not obliged to hold any particular piece of territory. By moving around, he can avoid undesirable confrontations and fight only at times and places of his choosing. By exacting a steady toll of casualties and by maintaining a state of general terror, he can hope to extend the conflict to the point where our disenchantment leads to a withdrawal or to an unfavorable negotiated peace.

With the rather considerable territory available to the enemy in South Vietnam and with his ability to obtain supplies and replacements quite adequate to his needs, searching operations on our part may well prove to be costly and disappointing. The history of other such conflicts, for example, the campaign in Malaya, shows that even a relatively small guerrilla force can hold out for several years against numerically far superior conventional forces.

One obvious answer to such a guerrilla strategy is to build man-supported physical barriers that restrict his movements and deny him needed supplies. It is our belief that construction and enforcement of such barriers may at certain times be a better use of our forces than searching operations.

If the area of enemy operations is sealed off by a barrier through which he cannot exfiltrate, he will eventually be obliged to give up or break through. If we assume that the barrier is sufficiently strong to defeat penetration by small groups, the foe will have to concentrate his forces for a conventional attack, thereby presenting a military opportunity for which our forces and weapons are more suited. If he decides to hold out, his area may be compressed within successively smaller perimeters until he is no longer able to sustain his forces. In any case, the barrier technique puts the initiative in our hands and permits us to terminate his operations at a pace of our choosing. It is clearly to be anticipated that the mere fact that his support from outside is cut off will have an important effect on the morale of all but the hard core of the guerrilla forces, and one could anticipate some considerable loss of fighting power through defections. The support of the indigenous noncombatant population will also be strongly affected by this factor.

Because of the large areas controlled by the enemy in South Vietnam and because of his easy access to Laos and Cambodia, an effective tactical barrier system will be quite extensive, involving many hundreds of miles of line. In the early stages, these barriers would require considerable forces for construction, patrol, and support, but these demands would be drastically reduced as the enemy is immobilized. In any case, the advantage to be gained by such a program might be sufficiently great as to justify the use of nearly all of our available forces, save only those needed to protect our bases.

An objection that can be raised against the concept of either the national boundary barrier or the tactical barrier is that it immobilizes our troops in a "defensive" posture while permitting the enemy to concentrate superior forces where he wishes to break through. This was, for example, the

experience of the French in North Vietnam, where defensive outposts were regularly overwhelmed by massive attacks before reinforcements could be brought to bear. In this connection, several points deserve discussion.

First, in a guerrilla war, the objective of the regular force must just be to encourage such concentrations, and the fact that these were too much for the French was not the fault of the barrier concept, but of the inability of the French to react to concentrations in force. With the immensely superior mobility of our present forces in South Vietnam, we should be able to make good use of any mechanism that locates and concentrates the enemy.

Second, the question of manpower is, of course, a central issue in the whole barrier concept. If one were to apply classical military doctrine regarding the maintenance of a static front line to determine how many troops are required for the extensive barrier lines contemplated here, one would certainly arrive at quite unacceptable numbers. It is, however, precisely in this area that the technical and productive strengths of the United States can be brought to bear. We believe that, by the use of suitable techniques and the products of technology, it is possible to reduce drastically the manpower required to maintain the integrity of a barrier.

As we envision the barrier system, it would consist, at least in part, of long stretches of an actual physical "barrier," consisting of mines, fences, and automatic interdiction and surveillance devices, maintained and patrolled along its length by a small force. This force would need to be strong enough only to insure against penetration by individuals or small groups. The physical barrier and its maintenance force would not be strong enough to prevent its breach by large concentrations of enemy forces. Here, however, our high mobility drastically changes the situation in our favor. In principle,

if we were able to move our forces quickly enough, we would need only a skeleton crew for patrolling a barrier, backed up by a mobile force no larger than that available to the enemy for a penetration. Since the enemy is in no condition to launch attacks with all his forces simultaneously, even smaller forces might suffice on our side. In any case, the required balance of forces would seem much more favorable than that required to engage and defeat a roving guerrilla army.

It is our belief that, even with no further development in technology and given adequate supplies of existing surveillance devices and adequate airlift capability, it should be possible to enforce the proposed barriers with a one-to-one ratio of friendly-to-enemy forces. Improvements in technology and careful design might well reduce this ratio.

In the foregoing discussion, we have proposed a system of tactical barriers which, if carried out literally, might be considerably more extensive than even the national boundary barrier. It is not our intent here to urge such systems to the exclusion of other tactics, or even to suggest that a general subdivision of the country on such a massive scale is the only solution to the problem. Clearly, one will continue to use a variety of both offensive and interdictive techniques as the occasion demands and as our capability permits. The point is that an aggressive development of barrier technology and the recognition that field improvisation is not adequate for extensive systems will give field commanders the option of using barriers at an earlier stage of the conflict than would be the case in the absence of such development. The objective is to replace manpower by equipment wherever possible and to bring the conflict to an end with minimum casualties.

Surveillance Barriers

An effective tactical barrier system subdividing the whole of South Vietnam, or even sealing off the central

highlands, will be costly in both manpower and materials, and it will be of prime importance to reduce as much as possible the extent of the areas to be sealed off. Presumably, there are large areas in which enemy forces do not operate at any given moment and it is possible that such areas could be secured by a single sweeping operation. If one could then bound such areas in a way that incursions would be discouraged or that successful incursions would be reported, one might consider such areas to be effectively controlled. This might be accomplished by a surveillance system consisting of a line of sensors or trip-wire-actuated reporting devices, which would record and report the passage of people across the line. A number of possibilities for such "surveillance barriers" come to mind immediately, and it is possible that a systematic development could lead to a convenient and versatile system which could be implanted by patrols or convoys or from the air, and could be remotely monitored. Such barriers could also be used in various aspects of the operations against guerrilla activities in the more densely populated areas.

C. BARRIER DESIGN

The "tactical" and "national boundary" barriers discussed above can be considered as two variants of a general class of extensive, manned barriers. A national boundary barrier constructed in peacetime and serving only to prevent infiltration is quite different from a two-sided barrier driven through enemy territory in the face of armed opposition. Still, all such barriers have certain essential features in common, and a study of one or two will serve to highlight requirements in design and technology that will find application in many other situations. We believe these requirements can best be developed, first, by a series of detailed design studies for typical sites, and second, by experiments in the field.

As an example of the kinds of questions expected to arise in such a study, and also to give some substance to the discussion, we can think of the specific problem of a two-sided line along an existing roadway. A case in point might be a line along Route 9 from Quang Tri, terminating in a fortified camp in the general area of Khe Sanh. Such a barrier would cut the enemy's north-south communications within Vietnam, would give access to some parts of the infiltration trails, and could form one leg of an eventual encirclement via the Da Krong River, A Luoi, and Route 923 to Hue.

Judging from available maps, Route 9 lies largely in a broad valley with a gentle rise, at least to the confluence of the Da Krong about 20 kilometers east of the border. We presume that the barrier would consist of two strips placed perhaps a kilometer or so to either side of the road. The strips themselves would consist of barbed-wire fences and minefields to a thickness of perhaps 100 meters or more, with cleared fields of fire several hundreds of meters outside. Watch posts and illuminating towers would be located at intervals to command the line, and listening devices planted in enemy-held territory would be monitored from these posts. At frequent intervals, helicopter landing pads would be cleared in the protected area between the lines, and pioneer roads would be cleared to give access to any threatened points. At particularly exposed points, emplacements for heavy weapons would be prepared. It is assumed that the lines would be of sufficient strength so that a light patrol would be able to prevent penetration by small enemy forces.

An essential part of the system is a highly mobile force, instantly available from a not-too-distant base. The base must include a sufficiently large force to protect its own perimeter and, at the same time, must be able to dispatch adequate forces to meet attempted enemy incursions. If we suppose

that the enemy is reduced to battalion-sized operations, it should be possible for a division-sized base to protect itself and still control a considerable length of line.

The length of line that can be controlled by a base force of given size depends on how large a force the enemy can assemble and how long he can be delayed in making the penetration. In regions where the enemy is known to have strength, we shall need closely spaced bases; where his forces are light, fewer protective forces will be needed. Presumably, to support a line some hundreds of kilometers long, several division-sized bases will be necessary, but since our forces can be shifted quickly, not all of these need be occupied in strength. Since the enemy lacks long-range mobility, it should be possible to anticipate his dispositions with sufficient accuracy to maintain an average one-to-one ratio within the action radius of any of our divisions.

The time factor imposes a severe requirement on the strength of the line and its patrol, and this will require judgment in the field. Generally speaking, the farther away the base, the stronger is the line required. As a possible order-of-magnitude specification, one might try to design the line so that it would delay a battalion-sized force for a time equal to the flying time to the nearest base. This might mean that a fairly extensive minefield and some local heavy weapons -- possibly rocket batteries -- would be needed for exposed sections of the line located as much as one hour from the base. Sensors, air surveillance, and forward patrols might be relied upon to give warning of impending large-scale attacks and to alert support forces.

Returning to the specific problem of constructing a two-sided barrier along a road or waterway line, one can begin to formulate some questions for study.

Clearing

Many kilometers of line will have to be cleared through mountainous jungle country. The clearing away of all except low ground cover will be required, not only for the physical barrier and its minefields, but also for fields of fire, trails, and landing strips. It is said to be possible with suitable machinery to clear some acres of heavily forested land in an hour. For the line under discussion here, this would not be prohibitive, but it is clear that rather large military forces would be required to carry such an operation through the territory in question. A possible alternative is burning. The necessary preliminary defoliation is well within our capacity, and it could be carried out selectively to avoid destruction of friendly habitations and crops. It is also possible that not all the clearing need be done at once; once the line is established, indigenous labor may be used to extend the clearing, and the patrols might gradually be reduced as the clearing proceeds.

Fencing

The fence should be strong enough to prevent sneak penetration and to keep casual people and animals out of the minefields. Barbed wire on posts or in concertina provides some means for doing this, but consideration should be given to a more effective design using minimum materials and manpower. The recent development at Fort Belvoir of a barbed ribbon may be useful. It is also possible that an inexpensive electrical system can be designed, possibly one that would give a warning shock on first encounter, followed by a lethal charge if the contact is repeated. Such a system could be powered by a buried cable within the protected area, backed up by local generating systems at the watch posts. The fence system should be provided with microphones to warn of tampering, and seismic detectors could be used to detect tunneling activities. Whatever

the design of the sensors and controls, attention should be given to unitizing the system for minimum installation effort. Convenient trenching and fence-laying machines will also be needed.

Minefields

The assumption that watch posts will be provided with electrical power in some form makes the idea of electrically fired mines attractive. Possibly, pressure pads could be laid out over large areas to actuate mines. Again, the labor problem suggests attention to the problem of mine planting; it is important that each mine command as large an area as possible. Extensive use of bounding mines which fire several feet above ground is indicated. Such mines should be equipped for both electrical and trip-wire actuation, and they should be designed for the maximum possible radius of action and for easy implantation. It may be possible to implant such mines with propellant charges or pnuematic driving, or even to resow with short-range rockets. A careful choice of the most suitable mixture of mine types should be made, and attention should be given to provision of labor-saving equipment for installation.

Sensors

Crucial to the integrity of a lightly patrolled line is intelligence about activities on the enemy side. Since our restriction is on manpower and not on equipment, we should plan to support any line with an extensive system of sensing devices. Among the possibilities that lie well within the capabilities of present technology are such devices as remote sound transmitters of the kind popularly sold as citizens' band transceivers, which could be placed along trails by forward patrols or could be dropped by air. It should not be impossible to code these in such a way that a hundred or so could be monitored from a single watch post. Devices for this purpose exist in the field, but they need to be miniaturized and mass produced.

An examination should be made of the applicability of other sensing devices, particularly those that are suitable for night operation, as moving-target radars, laser scan television, and infrared detectors. Such devices should presumably be located in protected watch posts as a part of the surveillance system, but remote cameras might also find application for special purposes. An attractive possibility would be the use of a simple camera combined with a tape loop, so that successive images could be automatically compared, with only changes being reported. It should be borne in mind that personnel in the watch posts and on patrol can easily be overwhelmed with useless information, and the surveillance system should be designed to avoid this and to respond only to true alarms.

D. SUMMARY

The technology of physical interdiction should be examined with a view to developing a set of versatile barrier systems capable of extension over hundreds of miles with a minimum commitment of manpower, either for installation or maintenance. Components should form an integrated, but flexible, family, and reliance on field improvisation should be avoided. As rapidly as new systems can be devised, they should be subjected to experimental field tests both in CONUS and in Vietnam. Such barriers would be backed up by, and would augment and enhance the effectiveness of, the highly mobile regular U.S. forces available for offensive operations against concentrated enemy forces.

A national boundary barrier, supported by such forces as the situation demands, can serve to isolate the war zone, to provide clear evidence of outside interference, and to contribute to ending the war without further escalation.

Tactical barriers encircling enemy-held areas and

supported by highly mobile forces can be used to isolate the enemy and force him to launch concentrated attacks against the barrier. With reasonable order-of-battle intelligence, it should be possible to dispose friendly forces so as to command large regions of the country with a one-to-one manpower ratio or less.

Light, unmanned surveillance barriers can be of assistance in controlling uncontested areas and in defining the regions of enemy operation. Such barriers could be laid as a part of armored patrol excursions, and they would give notice of enemy activities in previously "sanitized" regions.

II. MODEL FOR A NATIONAL BOUNDARY BARRIER

In order to give substance to a discussion of a possible barrier system on the boundary of South Vietnam, it is necessary to start with some fairly explicit model. The plan presented here is developed for this purpose. We are not certain that it represents a good approximation to a final design, but it should serve to illustrate the general philosophy on which a final design might be based.

Of crucial importance to the entire concept, and central to the design criteria, is the provision of a highly flexible system, capable of serving its purpose with a minimum force where the threat is small and of accommodating and supporting large combat organizations wherever the enemy chooses to concentrate. The strength of the line at any given point is only partially conditioned by its physical structure. Within broad limits, it can be strengthened or weakened by changing the disposition of forces.

In general, the forces responsible for defending the barrier will consist of rather light patrol units, of platoon or company size, based on the barrier itself, and strong, highly mobile reserve forces of battalion or brigade size based some distance to the rear. The mobile reserves will be parts of divisional units having other missions in the area, and the allocation and distribution of forces in reserve will be subject to day-to-day modification by the local commander in accordance with his estimate of the enemy's intent and capability. It is assumed that, in any given large sector, order-of-battle intelligence will be timely enough to permit maintenance of an

approximately one-to-one ratio of enemy-to-friendly strength. "Enemy strength" here must include forces within the sector and across the border. A "strength" ratio of one-to-one does not necessarily mean a one-to-one ratio of combat troops: Relative strength is affected by mobility, tactics, firepower, and intelligence.

A. PHYSICAL DESIGN OF THE BARRIER

We consider here a "medium" barrier, suited for moderately difficult terrain and intended to hold against company- or battalion-sized attacks. The physical arrangement will generally consist of a forward "forbidden" zone, a barrier strip, a secure zone, a second barrier strip, and a second forbidden zone.

Forbidden Zone

Where the condition of the terrain permits and political considerations do not contravene, one would regard a zone 10 to 15 kilometers deep in front of the barrier as being "forbidden," in the sense that military units found in this area would be subject to ground or air attack. This zone would be patrolled and held under air surveillance, but not occupied. The depth is determined mainly by a desire to be out of range of enemy artillery, but it is also determined by the fact that detection of an important enemy advance through the zone gives several hours warning to the barrier forces. The near part of the zone should be generously supplied with sensors and warning devices that give notice of nocturnal activity.

Barrier Strip

A strip about 500 meters wide is cleared to provide unobstructed vision and fields of fire. The scale here is determined largely by the range of small-arms fire. At the forward edge of the strip is a warning fence, then an electrified concertina barrier, and finally an extensive minefield. Again,

there will be emphasis on sensing devices, including trip flares and microphones to detect any activity in the strip.

Secure Zone

Between the two barrier strips is a "secure" zone, not necessarily cleared, but kept free of all but authorized persons. Depending upon terrain and other conditions, this zone may be from one to several kilometers wide. It should be wide enough to allow maneuver space, but generally, its width will be determined by the desire to keep barrier strips along adjacent ridge lines. In the secure zone is a roadway with frequent branches giving access to the lines: A pioneer trail is at the edge of each barrier strip. Also located at the edge of the strips are bunker-type outposts, at 0.5- to 1-kilometer intervals, depending upon terrain. The outposts are suitable for occupancy by from one to several fire teams, but they are in fact occupied only lightly, if at all, unless there is evidence of a penetration attempt. Routine surveillance is carried out by roving patrols that are hidden from the enemy, by closed-circuit-television installations, and by the sensing devices in the field.

Watch Posts

Located at about 10-kilometer intervals in the secure zone are the main watch posts, which serve as bases for the patrols, monitoring centers for the surveillance devices, control points for heavy weapons and remotely controlled ordnance, and communication centers for support forces and air strikes. On the average, two such posts will be manned by a company (184 men), but if enemy action threatens, the force can be augmented. The watch posts should be so designed as to be manageable by as little as one platoon, but they should be able to accommodate a full company or more in case of attack.

Support Bases

Located at some distance to the rear of the line are bases, or staging areas, for the mobile forces that supply the main strength of the barrier against determined attack. There may be several sets of such bases, for example, battalion-sized bases at 30-kilometer intervals, brigade bases at 60-kilometer intervals, or division-sized bases at 100- to 200-kilometer intervals. Since the flying time for 100 kilometers is not large compared to other fixed times involved in embarking and debarking troops, it seems possible that reserves might normally be concentrated in a few large bases, rather than being deployed in a succession of smaller areas nearer the line. It must be recalled that these bases are also subject to enemy attack and one would wish to keep the number of areas to be protected to a minimum.

In any case, some base areas will be needed, and these must be supplied with perimeter defense and should preferably be connected to the barrier line with roads. In addition, secondary staging areas should be prepared in the neighborhood of the barrier, or within the "secure" zone, to permit deployment of troops to strengthen the line when an attack is anticipated. The basic principle here is to prepare the ground in advance and to familiarize the mobile forces with the areas in which they may be fighting.

B. MANPOWER

Of decisive importance in the whole barrier system design is the reduction of the required patrol forces to the minimum possible complement. Although they serve an important purpose in restricting the enemy's mobility, the fact that the patrols must remain at the barrier precludes their use for other operations, and hence, their commitment entails some loss in overall flexibility. If the manpower assigned to patrol can be

held to 10 or 20 percent of the total combat force available, the commitment can probably be justified, but a greater fraction might represent a serious weakening in our overall capability.

The number of men required for patrol duty obviously depends on what is expected of them. At the minimum, we shall assume that they are intended mainly to gather intelligence, to inspect the barrier system regularly, and to report penetration attempts. They should, however, also be able to deal with penetrations by small groups and to induce some delay on more determined attacks. Given some rudimentary technical aids, it would seem that a force of 10 to 20 men per kilometer should be adequate for this task. While these men should be highly trained combat troops, the nature of their assignment is such that they would probably not need the extensive supporting organizations normally included in the divisional structure.

The mission of the patrols is one that is peculiarly susceptible to the application of technology. Because they operate from fixed posts along a fixed line, they may draw strong support from permanently installed surveillance devices, such as microphones, radar, and night-vision aids. They may also be furnished with armament far in excess of that which they would command in field operations. In terms of the equipment at their command, they should be more like aircraft pilots than foot soldiers. To reiterate the point: The patrols represent one of the costliest parts of the barrier system, and at the same time, their mission offers the greatest opportunities for technological support.

The commitment of combat support to the barrier is a sensitive function of the quality of intelligence. Evidently, some small forces will have to be stationed close to the barrier for quick response to surprise attack, but it is reasonable to assume that normal surveillance and intelligence will

give timely warning of impending action by large enemy units. If the development of such attacks is a matter of hours, our forces can be brought to bear even from quite long distances. Since the number of large-scale attacks that the enemy can mount simultaneously is limited, a single reserve unit can provide the necessary security for a long stretch of line and at the same time be available for other emergencies. As was indicated earlier, preparation of base areas of various sizes in the places where the threat is high will provide the defense with considerable flexibility. Even the largest staging areas for brigade or divisional units might profitably be duplicated several times within a divisional operating area. Each such staging area will itself require a security patrol, so some compromise between a desire for alternative sites and the undesirability of dissipating defenses must be found.

For any military operation, the number of friendly troops required is roughly proportional to the strength of the enemy. The proportionality factor depends sensitively on mobility, intelligence, and tactics, but for counterinsurgency actions, it is generally held to be considerably larger than one, perhaps three or more. With a barrier, or in fact with any holdings that require defense, there is an additional fixed requirement that is proportional to the length of the line or perimeter to be held. On the other hand, the existence of the barrier improves the force ratio in our favor by providing intelligence, by denying the enemy his supplies, and by forcing him to concentrate where we are prepared to meet him. In the extreme case where the enemy is forced to attack a fortified position, the required force ratio is considerably less than one.

For purposes of argument, we write an expression for the number of friendly troops in a given area as

$$F = aE + bL$$

where E is the number of enemy troops and L is the length

of the line. Without the barrier, in search-and-destroy operations, b is zero and a is a number that is certainly greater than one. With the barrier, the term bL enters, but if a is correspondingly reduced, the value of F for a given E may be lowered. If bL is only, say, 20 percent of aE , a reduction of a by about the same percentage would leave the total force ratio unchanged.

Evidently, the fraction of friendly forces committed to the line will vary greatly with the terrain, with the enemy threat, and with the quality of intelligence. It is precisely because of this variability that we require a high flexibility, both in the day-by-day distribution of patrol forces among the various watch posts and in the disposition of the mobile forces. For barriers that are near the scene of other operations, the reserves do double duty; if the barrier is remote from the scene (as it would be, for example, in Laos), the reserve commitment is entirely to the barrier.

As an illustrative example of what might be accomplished by taking full advantage of existing capabilities in mobility and in sophisticated warning systems and ordnance, we consider an extended sector of a barrier in "average" highland country, subject to an "average" enemy threat. We suppose that in a 240-kilometer sector, the enemy has the equivalent of one division. Order-of-battle intelligence is assumed to be adequate to give warning of a change from this strength by a significant fraction, and it is assumed that the enemy is capable of mounting attacks of no more than a few battalions at any one time. (This we take to define an "average" threat in a situation where the level of conflict has been reduced to the guerrilla stage.)

We now presume that one friendly division has been given the responsibility for the 240-kilometer sector from the barrier to a depth of 50 to 100 kilometers on our side. This

division has the twofold mission of seeking out and destroying that part of the enemy which is inside the barrier and of preventing penetration through the barrier from either side. For patrolling the barrier, we attach to the friendly division one special brigade of about 4000 men, plus such supplementary supporting personnel as may be needed at the division level. This brigade can furnish 48 platoons of 42 men each for manning the watch posts. One the average, then, a single watch post contains 84 men having responsibility for the post and for a five-kilometer stretch of the line in either direction. With sufficient surveillance aids, such a force should easily be able to mount the necessary patrols and to repel crossing attempts by groups of up to about 100 men. With adequate armament, it should be able to hold its post against attacks of company or multicompany size and to delay the penetration of even larger forces sufficiently long for mobile reserves to arrive.

Depending upon the disposition of the enemy, the divisional commander may wish to hold as much as a brigade in reserve for possible attacks on the barrier. The same brigade, however, can serve, at least in part, as reserves for other friendly forces, such as those engaged in search-and-destroy operations within the sector. Since the enemy's capacity to mount several large operations simultaneously is limited, the size of the reserves is determined by this capacity, rather than by the length of the line or by the number of positions to be defended. Clearly, the size of the reserve has to be sufficient to avoid dissipation through feints, but this margin of safety applies equally whether the enemy's target is the barrier itself or other operating forces.

We suggest, then, that if the operational area which includes the barrier segment is not too small, then order-of-battle intelligence is adequate to ensure that the friendly

force cannot be completely overwhelmed in a surprise attack. We also suggest that the forces held in reserve to support the barrier can also be the same forces in reserve for other operations, and that they should therefore not be regarded as being immobilized by the barrier duty.

In this admittedly idealized example, the number of troops actually attached to the barrier is only about eight per kilometer. (These men must be backed up, of course, by the usual support and logistic manpower in the theater. If the same ratio applies to the barrier units as is usually found in other combat units, the total number of military men in the theater to be associated with the barrier operation will be perhaps four to six times the number just given.)

III. OUTLINE FOR AN ENGINEERING STUDY OF BARRIERS

Ultimately, a barrier system has to be designed on the ground, at the location where it is to be used. Only in this way is it possible to determine how best to accommodate to the terrain, and only here can we make a realistic evaluation of the situation that will confront the builders and the patrol forces. Still, if we are to evolve efficient and versatile systems, a considerable development effort needs to be carried out to make the necessary components available and to provide a variety of integrated systems from which the field commander can choose.

A barrier development program should attack two related objectives:

- One of these objectives is to evolve appropriately balanced systems of passive and active barrier components, utilizing existing technology, with emphasis on organizing the necessary materials in such a way as to minimize the installation effort. Studies, including field tests, should be made to determine the best available techniques for land clearing, fence construction, mine laying, and installation of surveillance and fire support systems. Such studies should result in the evolution of efficient procedures for construction, and they should make it possible to design complete kits of equipment and materials for field use. Realistic field tests would reveal the need for specialized equipment and prefabricated units, which could be quickly developed. The emphasis in this phase of the study lies in the utilization of existing techniques and doctrine to make available systems that can be immediately realized.
- On the basis of needs recognized in detailed studies, the second objective should be to develop such technological innovations as may be possible for reducing manpower requirements, both in construction and in patrolling, and for increasing the security of the barrier system. Once

one has recognized the potentialities of barrier systems in augmenting or replacing manpower, it is certain that new devices will suggest themselves. Again, it should be emphasized that field tests with military units are essential in establishing realistic requirements and in testing new concepts.

To illustrate the nature of the problems, as well as some possible procedures for solutions, we adopt a morphological approach, enumerating various imaginable classes of barriers in various settings and then discussing some selected problems.

A. BARRIER STRENGTH

To indicate the intended strength of a barrier system, we shall refer to "light," "medium," and "strong" barriers. A "light" barrier is expected only to delay the passage of small bands (10 to 20 men) and to give notice of their passage. Such a barrier might be used on a road or railroad through comparatively uncontested territory to give patrols adequate notice of ambushes or sabotage. By a "medium" barrier, we mean one that is sufficiently strong and sufficiently well defended to prevent crossing by bands of 20 to 50 men and to protect its patrol forces against company-sized attacks. It is expected that a sufficiently determined enemy will be able to penetrate such a barrier, but that the patrol forces themselves can hold out for reinforcements, even in the face of an attack involving a hundred men or more. A "strong" barrier is intended to prevent penetration by company-sized units and, in the event of attack on battalion scale, to induce sufficient delay to permit arrival of adequate reinforcements. In all three cases, we draw a distinction between the ability of the barrier and its patrol forces to defeat a penetration attempt and the ability of the patrol forces to protect themselves and their watch posts. A successful penetration through the barrier is more acceptable than the loss of a patrol.

Within rather broad limits, the strength of the barrier

at a given point depends mainly on the size of the patrol forces and the speed with which the mobile reserve units can be brought into action. These numbers can be changed by redistribution within a sector from day to day, or on a somewhat longer time scale, by reinforcement from other sectors. By this means, a "light" barrier can be converted to "medium," or "medium" can be converted to "strong," in response to changing appreciation of the enemy's disposition.

It should be noted that in none of these levels is the patrol force expected to "hold at all cost" against greatly superior forces. In most situations, the barrier has served its purpose if it forces the enemy to mass his men; even if he penetrates, he is vulnerable for some considerable time, and little has been lost by the penetration. These remarks do not apply, of course, to perimeter defenses around vital bases or ports; such defenses must be designed to meet every contingency and, in general, they must be much more heavily manned than barriers that are intended to control infiltration or to reduce the enemy's ability to conduct guerrilla warfare.

It is not intended here to suggest that the barrier is automatically penetrable by a sufficiently determined enemy, but rather that the commander responsible for a given sector can adjust the strength of the barrier in accordance with his best estimate of the enemy's current capability. If he grossly overestimates that capability, he ties his forces down unnecessarily; if he underestimates, he is not confronted with catastrophe.

A further point about barrier strength is the observation that imposition of the barrier may in itself increase the tactical hazard. On a "light" barrier, the patrols and patrol posts will offer attractive targets that did not exist before, and they must be protected. It is partly for this reason that separate requirements are stated for the protection of the

barrier and its patrols. If, for example, one envisages a patrol force of a few dozen men responsible for several kilometers of road, it is not to be expected that this patrol can defeat a penetration by a band of a hundred men; it is expected, however, that in the face of such an attack they should be able to hold the base or post from which they operate. The same observation applies to the support forces, those highly mobile units that we visualize as being on call to any threatened part of the line. It will be necessary to prepare many substantial bases for the mobile support units along an extended barrier, but these bases may be lightly or heavily occupied, according to the tactical situation. Just as is the case for the patrols, the protection of these forces is more important than the protection of the barrier. If the enemy succeeds in massing forces that are too large for the available response, the position should be abandoned until an adequate counterattack can be mounted. Among other things, this implies that an evacuation plan would be worked out for every post and every base, including necessary demolition of stores.

B. ENVIRONMENT

Having established some tentative categories in which the strengths of the barriers can be examined, we should consider the various environmental factors that affect design. Broadly speaking, we shall be concerned with three general types of terrain: swamp land, particularly in the delta region; flat, forested land, as in the plains and plateau regions; and mountainous territory, as in the northern highlands. Each of these poses special problems and offers special opportunities. For each, we shall have to consider separately the questions of the physical barrier design, the character of the patrol forces, and the disposition of the support forces. In particular, the availability of roads or the possibility of building roads will have a bearing on the all-weather capability for quick response to alarms.

The design and disposition of barriers will also depend upon the degree of economic development in the area. Regions that are highly cultivated or heavily populated will present special difficulties, if we are to avoid alienating the population. On the other hand, the securing of just such regions could well be a major objective of a barrier program. Similarly, the securing of vital roads, railways, and power transmission lines may require either some interference with the local population or special measures to guard against sabotage.

Crucial in the construction phase will be an estimate of the enemy's capabilities. Evidently, where enemy activity is light, long stretches can be built simultaneously, and large construction crews can be used. Where strong enemy action is to be anticipated, the working area must be limited, in order that it can be adequately protected. In these circumstances, techniques must be evolved for continuous construction by a concentrated force carrying out all phases simultaneously. Logistics and operating plans must be closely coordinated so that the ground is secured and the barrier completed in a continuous operation. Clearly, a high degree of mechanization is much to be desired here, and the design of suitable specialized construction equipment is part of the problem.

C. COUNTERMEASURES

Finally, the design must take into account the countermeasures available to the enemy. For temporary barriers intended for surveillance or for denial operations over a limited time, countermeasures will be limited to equipment and techniques available in the immediate locality. For a permanent barrier, however, it will be necessary to anticipate the enemy's longer range capability. For example, we have as yet seen very little use of artillery by the enemy, yet we know that he has such weapons and that he has the skill to deploy them. It

follows that our barrier systems must at least provide for the necessary protection of men and vital equipment against harassing artillery fire, and they should include plans for emplacements suitable for counterbattery fire.

We have also seen little air activity on the part of the enemy so far, and presumably we should have warning of any drastic increase in his air capability. Still, the use of helicopters, gliders, transport aircraft, or even strike aircraft is a possibility open to him, which should not be ignored. We should be prepared at least to provide the barrier posts with warning systems and antiaircraft weapons, if the need for them arises. Such a warning system might incidentally become an important function of the barrier if enemy air operations threaten population centers or rear-area bases.

By far, the most important counter-countermeasure is timely intelligence. The barrier alone is a powerful contributor to the intelligence system, since the enemy cannot cross it in strength without revealing his presence. At the same time, the existence of the watch posts provides an opportunity for controlling and monitoring a local sensor system in any desired degree of detail. Emphasis should be given to the provision of a variety of sensor systems both along the line and deep into enemy territory.

D. COMPONENTS OF A BARRIER SYSTEM

The foregoing discussion establishes a multidimensional classification matrix of barriers of various strengths, in various environments, and subject to varying degrees of counteractivity. For each track through this matrix, we have a specific design problem in which the manifold of components making up the system will have to be considered. Here, we discuss some of the design problems individually, bearing in mind that the completed barrier must include a judicious integration of many components into a working system.

Route Selection

For the national border barrier, we have severe constraints in the choice of the line to be followed, since we do not wish to give up too much territory and we cannot afford to leave large pockets that can be represented as sources of "indigenous" insurgents. In those regions of the highlands where concerted attacks on the barrier are likely, it would be desirable to have a several-kilometer-wide zone between the border and the actual barrier. In this zone, roving patrols and planted sensors would provide information on enemy concentrations, and strike forces would attack any that were found. Where possible, one would like to have this zone sufficiently deep that artillery pieces which threaten the line could be dealt with by ground forces without crossing the border.

A possible alternative would be to place the barrier at the border and to deal with threatening forces in the next 10 or 20 kilometers by air strikes and artillery. It will be important, however, to be able to operate patrols for some considerable distance in front of the barrier in order to gather necessary intelligence.

A flexibility of 10 or 20 kilometers in the location of the barrier with respect to the boundary will make it possible to take advantage of terrain features and greatly simplify the construction of the line. For example, some two to five kilometers south of the demilitarized zone, the valley of the Cam Lo River runs through a large fraction of the 40-odd kilometers of inhospitable forest and mountain region to the Laotian border. Through this valley, construction of roadways and clearings for the barrier should be less difficult than along the tortuous up and down path of the demarcation boundary itself. A still more attractive route lies some 10 to 15 kilometers farther south, where the valleys are broader and the gorges less numerous. Here, relatively short roads would give access from Route 9.

Also in the region of the demilitarized zone is an example of another consideration in route selection. From the seacoast into the foothills, 30 kilometers inland, lies an important agricultural area, which must be included within the barrier. Here, then, the barrier must be at the boundary, come what may. Fortunately, this area is flat and it should present no problem as far as surveillance is concerned. A precedent already exists for our taking action within the demilitarized zone if a threat develops there.

This brief discussion will perhaps suffice to emphasize the point that a major consideration in the design study must be a detailed examination of the terrain and a careful choice of the route in order to make the best possible compromise between the political, military, engineering, and economic requirements. A further point can be injected here: Some parts of the barrier system, particularly the roads and the cleared areas, can ultimately have considerable value in a civilian economy. Some weight should also be given to this aspect in laying out the barrier system and its supporting lines of communication.

Clearing

A cleared strip of land, affording direct visual observation and unobstructed fields of fire, will be a basic element in most barrier systems. In some cases, only 100 meters or so will be needed, but most often one will require at least one 500-meter (range of small arms) cleared strip for each side of the barrier (we assume here that most barriers will have to resist attack from either side). Sometimes, the cleared strips will be contiguous, with a road running between; at other times they may be separated by a several-kilometer-wide secure zone.

The following tabulation[2] indicates the general character

[2]Extracted from, Border Control Problems in South Vietnam, RAND Corporation RM-3967-ARPA, June 1964, SECRET.

of the terrain for a national boundary barrier:

Slope Class	Kilometers of Border	Vegetation
25 to 40 Percent	480	Mostly forested
5 to 25 Percent	210	Mostly forested
Less than 5 Percent	350	Mostly forested
Flat Delta	400	Swamps, rice fields

In the same reference, it is stated that a Le Tourneau G-40 electric tree crusher can clear three to seven acres per hour and can work on slopes of up to 45 degrees. An independent study[3] reports that two D-9 tractors working with a heavy ball and chain, can clear ten acres per hour of trees up to 25 inches in diameter. Clearing is slower on steep slopes.

A 1-kilometer strip is equivalent to about 250 acres per kilometer of length. Three G-40 machines, or three pairs of D-9 tractors, could thus clear about 1 kilometer per eight-hour day in heavily forested terrain. If we take this as being average for the 1000 kilometers of forested country, and if we assume three crews of six men to operate and support the equipment, we find that we need only 18 men (plus support and protection personnel) to press the rough clearing forward at one kilometer per day. This part does not seem to present any great difficulty, except under the most extreme terrain conditions, but again, detailed examination of a variety of sites will be necessary for realistic planning.

Finish clearing -- disposal of trees, removal of brush cover, and general cleanup -- seems to be a more difficult problem. According to FM 5-34, "medium" clearing is likely to proceed at about one-fourth acre per hour per bulldozer. At this rate, one would need 125 men to clear one square kilometer per eight-hour day. Possibly, the brush material can be

[3]ES66, Engineer Strategic Studies Group, Draft Report, July 1966.

stacked for later burning, but additional manpower will be needed to deal with trees. To some extent, this cost is offset by the fact that the trees will supply logs and lumber for construction and thereby reduce the logistic burden. If we take as a guess some 5000 24-inch trees per square kilometer and assume two man-hours apiece for lopping and cutting into lengths, we need 1250 men to deal with these trees in one day. The study should develop a better estimate for the amount of material to be disposed of, and it should consider whether a large-scale version of the familiar slash grinder would ameliorate the situation. It is also possible that one should set up sawmills and produce lumber for construction use.

An important problem arises in connection with the maintenance of the cleared strips. If new growth is to be cleared by scraping, the minefield will have to be removed, at some considerable expense. The alternative of chemical treatment should be investigated, but this is likely also to be costly. Another possibility is to plant low-growing grasses or weeds that would inhibit other growth. One could also use "gravel" mines with a life of some months and then clear by scraping or plowing.

With the present crude estimates, we arrive at 1400 man-days per kilometer as the cost of clearing. To this must be added the support and supervisory personnel and combat forces to protect the crews. The estimate is uncertain by at least a factor of two, either way.

Roads

A principal point of emphasis in the barrier design problem is maximum mobility, both for the patrols along the line and for support units to any threatened point. There must be at least one road parallel to the line in a secure zone, preferably disposed so that traffic cannot be monitored by the enemy. There will presumably also be side roads, generally of

a pioneer type, and occasional roads leading to support bases in the rear.

In the northern 200- to 300-kilometer sector, road building will be quite difficult and expensive. However, in part of this region trails, old roads, and river courses lie roughly parallel to the border within 10 to 20 kilometers of it, and consideration should be given to locating the line on these tracks, at least initially. It should be borne in mind that terrain that is particularly inaccessible for road construction is also likely to be difficult for the infiltrator and it will require a less elaborate barrier.

The manpower cost of road building will probably be a major part of the whole construction cost, and hence, this needs careful estimating, with detailed maps and photographs. As an order-of-magnitude guess, we shall assume one kilometer of one-lane gravel road per kilometer of line and multiply by two to include side roads of various classes. Excluding the southern third (plains and swamp), we take half the line to be characterized as "hilly, forested" and half to be "mountain, some rock." FM 101-10 gives 5600 and 19,500 man-hours per mile for grading and applying six inches of gravel for one-lane roads of these two classes. Taking the average and multiplying by two, we obtain 12,600 x 5/8 x 1/8 x 2, or 2000 man-days per kilometer of line. This number might easily be doubled, if wider or more substantial roads are needed.

Opportunities for development in this area seem rather limited, since road building is already a highly developed and highly mechanized skill in the United States. The principal contribution of the study will probably lie in a meticulous planning of the routes and anticipation of special terrain problems. A realistic cost estimate will be crucial in determining the extent to which the barrier line should be adjusted to make use of existing roads.

Obstacles

It is not clear to what extent man-made obstacles other than wire barricades should be used. Of prime importance in defending the line is clear visibility and clear fields of fire. However, an important exception seems to be presented by a water barrier, since men find water difficult to cross, and they are highly vulnerable to attack in water. Where watercourses are available, or where canals can be dug, they should be incorporated into the barrier system. If the water is still, hydrophones will provide a sensitive means for detecting clandestine activity. The water can also be covered with marking or odoriferous chemicals to assist in identifying and tracing trespassers. A water barrier, particularly a stream or any other place where the water table is near ground level, is also a strong countermeasure to tunneling.

A deep trench, which can easily be dug by heavy machinery during the clearing operation, also furnishes an obstacle, but unless the trench is aligned with observation posts or can be kept under surveillance from high positions, it offers concealment to the enemy. The question of the usefulness of other special obstacles deserves further study.

Wire Barriers

As a first approach to the problem, it appears that the triple standard concertina offers a good solution. Such a fence is transparent, it can be cut only with special tools, and it provides an excellent barrier. Field-erected barbed-wire barriers are less expensive in material, but they require a great deal of manpower and they can be cut through with ordinary pliers.

From FM 5-15 we find that a triple standard concertina requires 100 man-hours per kilometer for erection and involves 7.9 metric tons of material. Assuming two such barriers and

increasing the requirements by 50 percent to allow for various single-strand warning fences that will be needed, we find 300/8 or 40 man-days per kilometer as the requirement for construction. This number can doubtless be reduced by providing simple mechanical equipment for driving stakes and stringing wire directly from trucks.

A considerable increase in the impenetrability of a wire barrier can be obtained by electrification. Since there must in any case be electric power available for the watch posts and for illumination, electrification of the fence offers no difficulty beyond the problem of insulating it from the ground. Here, consideration should be given to the possibility of furnishing all stakes and pickets with appropriate insulation. It should not be difficult, for example, to sheathe the entire stake with a sufficient thickness of plastic or ceramic material to provide good insulation, even in wet weather. Probably a 2200-volt supply capable of delivering a few amperes is adequate for a killing fence. Warning fences should be electrified for shock only, in the same fashion as cattle fences.

Insulation of a concertina coil from the ground presents a difficulty. If it is not possible to suspend it on insulated stakes, one could consider laying plastic sheet (a few mils thick) underneath. Such a sheet would also inhibit plant growth and reduce the maintenance problem. It will be important to provide separate circuits for various sections of fence, so that failure at one point does not affect the whole line. Needless to say, there should be no exposed metallic ground lines, since the obvious countermeasures would be a simple jumper to short-circuit the line. It is unlikely that one could defeat the line by connecting it to a stake driven into the ground, but this possibility should be tested. Development of prefabricated harness, distribution, and switch-gear will much reduce the manpower required to electrify the fence, and

will minimize failures in the field. A panel should be provided at the watch post, with indicators to report any significant changes in load.

Minefields

According to FM 20-32, a "standard" barrier-type minefield, with three antitank mines, four fragmentation antipersonnel mines, and eight blast antipersonnel mines per meter requires 5830 man-hours per kilometer for installation. For two fields, then, we have about 1500 man-days for hand laying. This is clearly a massive effort, and any possibilities for mechanization or for reducing the number of mines to be laid should be carefully examined. Reducing the number of antitank mines (or eliminating them completely) will have a significant effect on the logistic problem, but rather little effect on the installation time.

It would seem important to study this question carefully, to see if some simple and useful devices can be developed. Development of a mechanical mine planter ("Dan Patch") has been reported, but the machine is not available. Mines could perhaps be developed in a tubular form to be driven into the ground by a pneumatic hammer with automatic feed. Fuzing and arming would still be carried out by hand, but the enormous burden of digging and hauling would be eliminated.

Attention needs to be given to the matter of optimum minefield design for the conditions to be encountered. It is possible that extensive use should be made of trip-wire-actuated bounding mines to give a large radius of action. The possibility of large-area pressure pads -- either pneumatic or electrical -- to activate the mines should be considered. In view of the high cost of mine planting, one can afford more expensive mines if the installation effort is thereby reduced.

Alternative types of minefields should also be exhaustively considered. "Gravel" mines are easily dispensed and can be

used for temporary closures or defensive perimeters during the construction phase. Command Claymore mines are very effective in some circumstances and they are easily disarmed for friendly passage. One could perhaps use electrical firing for trip-wire mines, with remote power sources that could be disconnected when the field is to be entered by friendly troops. Considerable care should be exercised to make sure that the field can be adequately cleared if it is ever to revert to civilian occupation. The minefield and, in fact, the whole barrier system, will be subject to continuous evolution and modification as the enemy develops countermeasures.

Outposts, Watchtowers

At intervals of about 500 meters, some form of bunker or watchtower will be required. This may vary from a simple revetment into which an armed personnel carrier can drive, to a more elaborate installation with prepared weapons mounts, searchlights, and surveillance devices. Here, as at the main watch posts, the emphasis is on providing the maximum mechanical aids for very limited manpower. One should not hesitate to spend several tens of thousands of dollars to equip each outpost, if this will appreciably reduce the manpower requirement.

For a two-man machine gun emplacement, FM 5-15 estimates 28 man-hours for hand construction. Evidently, one would wish to plan for a considerably more elaborate structure, but at the same time much of the work can be expedited by machinery. The construction effort is in any case only a few man-days and is not significant in comparison to the clearance, roads, and other operations. Here, some attention should be given to the advantage of prefabricated construction for burial or erection in the field, but standard techniques with the use of dressed lumber or sheet metal should be quite adequate. Where watchtowers are used, one should again consider prefabrication, but

again the reduction in the logistic burden by using locally produced lumber should be taken into account.

More important will be the development of such devices as remote-controlled searchlights and night-vision aids for these outposts. Possibly, the lights should also be controllable from the main watch post, so that the enemy cannot know whether a given outpost is occupied. In areas where the enemy threat is serious, the outposts should be generously designed to accommodate several fire teams, and secondary positions with interconnecting trenches should be installed. It should not be difficult for such an outpost to defeat a frontal attack through the minefield with a manpower ratio of 1:5 or more, but evacuation and demolition plans should be available in case of an overwhelming attack.

In mountainous terrain, careful attention must be given to locating the posts so that no parts of the line are obscured from view.

Main Watch Posts

It is contemplated that strongly defended posts, normally occupied by perhaps 80 men, should be placed at about 10-kilometer intervals. These watch posts will be headquarters for the patrols and central collecting points for all intelligence and surveillance information. They will contain electric power generators to supply fence electrification, illumination, and general-purpose power. Presumably, a line of posts will be supplied by underground power transmission cables, so that the local generator can be used as an auxiliary only.

The watch posts have two main missions: to monitor information on any activity in the given sector and take the indicated action, and to protect themselves against direct attack. As is the case for the outposts, a considerable investment in equipment and armament can be justified. Depending upon

circumstances, watch posts may or may not be equipped with such support as kitchens or recreation facilities.

In its self-defense role, the watch post must be designed with an adequate arsenal and a large number of well-connected weapon emplacements. It should be capable of putting up a reasonable defense with only a fraction of its normal manpower complement, and at the same time, it should be prepared to accommodate reinforcements to the extent of several times the normal complement. Since the position is prepared in advance, it can be supplied with mortars and other heavy arms far in excess of the normal for a platoon or company organization.

Consideration might well be given to the provision of extensive rocket batteries. Although the large-scale use of rockets may impose a somewhat greater logistic burden than the equivalent in mortar tubes and shells, rockets are capable of a high rate of fire. For example, an installation small enough to be carried in a truck can easily fire 120 rounds of 4.5-inch rockets in a few minutes. Variants of such installations were extensively used in amphibious operations during World War II and in Vietnam. It is also possible to fire rockets directly from their shipping crates. With judicious disposition of such installation along the barrier line, quite heavy fire can be delivered at critical points by remote control from the watch post. Rocket salvos may also be effective in counter-fire against mortars.

The construction cost for the watch post is difficult to assess. If one relies mainly on earth cover, a great deal can be done by mechanical digging supplemented with timber construction. Again, one might consider prefabricated structures for burial in the field. Deep trenching will be needed to secure electric power and communication and command circuits. A helicopter pad, and possibly an airstrip, should be included in the plan. As was the case for the outposts, it is a fair

guess that construction manpower will be small compared to that needed for other components of the barrier.

Surveillance

The primary element in the surveillance system will probably be the patrols along the line, in forward areas, and in the air. During daylight, surveillance along the line should present no difficulties, but the problem at night and in rainy weather is quite severe. Among the possible devices that may be of assistance, we enumerate the following:

- Microphones on Wire Fences. Sound is well transmitted on wires and any clipping operations should give an unmistakable signal.
- Electrical Detectors. If the fences are electrified, changes in current will provide evidence of tampering. Nonelectrified, but insulated, fences can be equipped with capacitance-operated or resistance-sensitive alarms to indicate the passage of persons or cutting of wires. Trip-wire systems can monitor passage along trails.
- Microphones in Forward Areas. A modification of the sonobuoy system can be emplaced in the forward area, either from the ground or by helicopter. With some small risk, microphones can be connected by direct wire to the watch posts. Simple electronic devices could monitor a hundred channels or more and report any significant change in sound level. In open areas, remote-controlled directional listening devices along the line itself could be useful.
- Night-Vision Aids. Closed-circuit television systems are highly developed, rugged, and inexpensive. Camera stations can be disposed along the line, perhaps at the outposts, and equipped with a programmed traverse system to scan the line periodically. If a searchlight is arranged to traverse with the camera, only the immediate field of view need be illuminated. A recently developed laser device eliminates the need for the searchlight and makes unobtrusive observation over a large area possible. The rate of scanning should be selected to provide a continuous natural scan at the monitor station. With perhaps 20 such cameras reporting to the main watch post, it should be possible for one man to monitor an entire 10-kilometer sector. It may be important here to consider a comparator system, possibly involving a simple magnetic tape loop, so that only changes between successive images of the field would be exhibited. All elements for such a system either exist now or can easily be adapted from

available devices. An intriguing possibility is that of coupling a remotely operated machine gun to the camera traverse system to permit aimed aire, controlled from the watch post.

Infrared and moving-target-indicating radar gear will have important advantages at night or in bad-weather operations. The possibility of obtaining suitable equipment for widespread use along the line should be examined.

- Animals. Trained dogs should be invaluable for patrolling operations. Consideration should be given to the possibility of using other animals, particularly nocturnal animals or birds whose activity would reveal intruders.
- Ultrasonic Scattering Detectors. With a single powerful ultrasonic transmitter and several appropriately located microphones, changes in the disposition of scattering objects can be detected. Alternatively, one can use a pulse-and-listen sequence and look for changes in the shape of the backscattered pulse. Some modification of the sonar system might serve the purpose.
- Laser Beam. In reasonably flat terrain, a highly collimated laser beam can be propagated close to the ground and returned over a path of many kilometers. Interruption of the beam would signal an intruder. One should investigate whether a high-power pulsed laser beam could be used to blind snipers.
- Seismic Detectors. Tunneling will be a serious problem in some areas. It is possible that an inexpensive and sensitive transducer could be developed for burial at frequent intervals along the line. Quite satisfactory seismic detectors exist in the field, but they are rather expensive in their present form.

Friend-or-Foe Identification

In many localities, the roadway may have to carry civilian traffic, at least during the day. The security of the line will then require that checkpoints be established where cargoes can be checked and the number of people entering and leaving the zone can be controlled. Systems will be needed for detecting arms and for validating identification papers. It may be necessary to use convoys with escorts to prevent clandestine entry into the zone. At the end of the day, the secure zone must be swept, and there may be a need for technical devices here.

Another problem is posed by the population that is indigenous to the countryside. These people will either have to be kept out of the barrier zone or contained within it. A strongly enforced prohibition against weapons will be necessary, and here again, a sensitive, portable detector is needed.

Battleground Preparation

Basic to the whole purpose of the barrier is the ability of mobile forces to respond quickly to any important penetration attempt and to bring their force to bear immediately upon arrival. At the least, this requires preselected and prepared helicopter landing areas and extensive road and trail systems, both within and outside the barrier area. Sites for this purpose preferably should be cleared during the initial construction, when heavy equipment is available. Exercises in the field will suggest other preparatory measures, which can be implemented as time permits. A heavy rocket barrage, controlled from the watch post, would be effective in clearing landing zones outside the secure area of enemy troops and booby traps just before a landing.

Navigation Aids

Quite possibly, the most common response to detected enemy activity will be to call in an air strike. With permanent posts and a well-marked line, it should be possible to guide such missions to their targets with sufficient accuracy even for blind bombing. Consideration should be given to selecting an appropriate beacon system with simple coding, so the pilot can locate himself quickly and precisely. A simple system of controllable lights can aid him in his approach.

Water Barriers

Special problems are posed by barriers in swamps or flooded lands. Here, it is possible that the main element of the barrier would be a dredged channel, with an embankment on one

side. In some areas of the delta, the level in such a channel will vary up to 15 feet, depending upon the season. Attention needs to be given here to all of the elements just discussed, with specialization in regard to this peculiar environment.

E. CONCLUSION

We have outlined here some of the problems that should be attacked in any broad study of barrier design. In some cases, what is needed are firmer plans and solider cost estimates. In others, there are specific technological problems to be solved, and there are broad opportunities for improvements in construction, patrol, or support operations. From the point of view of minimizing the construction effort, the crucial problems lie in clearing, road building, and mine laying: These together represent something on the order of 20 man-years per kilometer, give or take a factor of two. Once the construction phase is completed, the problem will be to introduce the maximum possible automation into the surveillance and defense system: This is a problem in which imaginative technical developments will produce rich returns.

Appendix

THE ALGERIAN BARRIER

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One of the key military operations of the Algerian war from 1957 to 1959 was the successful completion of a virtually impenetrable barrier, which completely closed off the eastern border of Algeria with Tunisia and the western border with Morocco. This barrier, together with the establishment by General Challe in 1959 of a highly mobile strategic striking force engaged in hunt-and-kill operations within Algeria, was in a period of about one year able to decimate the rebel forces and bring the Algerian conflict to a successful <u>military</u> conclusion. Since the barrier operation in Algeria has many potential parallels with a similar possible operation in Vietnam, we summarize in this appendix some of the key facts and try to make some comparisons with the Vietnam situation.[1]

The Algerian barrier consisted of two independent north-south barriers running along the eastern and western borders of Algeria from the sea to the Sahara Desert. Each barrier was about 600 miles long, for a total of 1200 miles. Although the physical barrier was not extended along the southern border of Algeria, this quarter was sealed off by an effective blockade based on the near inaccessibility through the Sahara desert, augmented by air surveillance and interdiction. The complete barrier provided near-perfect isolation of Algeria from its neighbors and isolated the 40,000 trained and armed rebels within Algeria from a comparable number in Tunisia and Morocco. Within the barrier were the Algerian population of

[1]Much of the material has been gleaned from statements of French officers which appear in a RAND memorandum, RM-3653-PR (1963).

about 9 million, among which there were (in 1958) about 40,000 well-trained and armed Algerian rebels, plus perhaps 80,000 "provincial forces" of helpers and partially armed local belligerents. Outside of the barrier were an additional 40,000 trained and armed Algerian rebels, as well as a source of materiel and personnel support in Tunisia and Morocco. The majority of the population of Algeria, including over half a million French veterans -- of which some 200,000 served in military or local defense units -- were sympathetic to the French side.

During this period, the French military forces numbered approximately 400,000 men, distributed as follows: 350,000 army, 40,000 air force, and 8000 navy. Of these forces, 80,000 were assigned to the construction and maintenance of the barrier, 180,000 were engaged in "quadrillage" (protection of towns), 20,000 comprised a highly mobile strategic striking force, and 120,000 were assigned to support functions.

The cost of the physical components of the barrier varied from region to region, depending on the local conditions, but it has been estimated at about $20,000 per mile for the initial installation. This would imply a total initial cost of some $25 million.

The physical elements of the barrier varied somewhat from place to place, but they consisted generally of the following:

- Barbed-wire entanglements and a minefield distributed in a strip 20 to 30 meters wide.
- An electrified fence with power sources and detecting stations about 10 kilometers apart. The fence was not intended to kill, but it was equipped with detectors (nature unknown to us) which gave indication of any serious disturbance.
- Ground radar to detect vehicles, especially in plateau regions, spaced 25 to 40 kilometers apart.
- Searchlights, especially in hilly regions.

The fence was continually modified -- each segment being

augmented or changed in some way about once each month. Ultimately, the line along the eastern border of Algeria was made of a double fence a few miles apart for a length of 600 miles.

The physical barrier was backed up by military personnel averaging about 70 men per kilometer. For example, one 50-kilometer section bordering Tunisia was monitored by a single command with 3500 men. This command had other responsibilities for protecting a sector about 50 kilometers on a side, but its first priority was the security of the barrier.

Routine surveillance of the barrier was provided by individual companies spaced at 6- to 8-kilometer intervals. These companies gave minimal surveillance during the daytime, occasionally with the help of light observation aircraft. The most intense activity against the fence was at night, so the fence was patrolled by small mobile units in light armored cars or scout cars. Each point on the fence was covered at intervals of 10 to 15 minutes during the night.

When an attempted penetration was detected -- and confirmed by observation of cut wire or tire tracks -- there was a general alert in the sector and preplanned netting operations were put into effect. These attempted to contain the intruders until dawn when they could be tracked down and killed. Such alerts occurred as frequently as once each week along a 50-kilometer piece of the fence.

It is asserted that after 1959 there was no significant penetration of the barrier.

It is tempting to dismiss the Algerian barrier as being of little relevance to Vietnam because of the difference in terrain. But although there are important differences, the Algerian frontier is not as favorable as one might think. For example, let's look at the nature of the terrain along the eastern border. The first 250 kilometers south from the Mediterranian Sea consist of rugged, mountainous country with

elevations ranging mostly from 3000 to 6000 feet. There are many ravines, and there are peaks which rise to 7500 feet. There are up to 45 inches of rainfall and a climate that produces regions of heavy natural vegetation (for example, cork tree forests), as well as cultivated orchards. Some of the forests have served as bandit refuges for years. Toward the south, the countryside tapers into a denuded plateau covered with scrub bush and briar with heights of three to six feet, and the next 300 kilometers are low, dry plateaus of a similar nature. Then come about 800 kilometers or so of desert. The northern part differs from Vietnam perhaps primarily in that the temperate-zone type of vegetation is less dense than the Vietnamese jungles. Also, the terrain is probably somewhat less rugged than that in Vietnam.

It does appear, however, that the nature of the problem, the scale, and the other similarities would warrant a more detailed study of the Algerian barrier operation and an attempt to appraise the aspects that might be applicable -- with suitable modifications -- to a national border barrier in Vietnam.

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13. ABSTRACT

The argument presented in this report is that the character of the conflict in Vietnam is such that a far greater use of barriers than is the case for more conventional operations is indicated. Technological advances, especially in the use of helicopters to move troops quickly, make barrier systems much more economical in manpower than in the past. Developments such as new types of sensors, moving-target radar, infrared detectors, and night-vision devices can contribute to tactical and strategic advantage in the use of such systems. An appendix discusses the French experience in the use of the Algerian barrier. (S)

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